ecology and environment, inc.
1776 SOUTH JACKSON STREET, DENVER, COLORADO 80210, TEL. 303-757-4984
International Specialists in the Environment

MEMORANDUM

To: Joyce Ackerman
EPA OSC
From: Mike Sullivan
E & E TAT
Date: August 21, 1995
Subject: Site Inspection, H_2S Release, PSCo Reservoir, Weld County Colorado, TDD# T08-9508-0017

INTRODUCTION

The U. S. Environmental Protection Agency - Emergency Response Branch (EPA) tasked the Ecology & Environment, Inc., Technical Assistance Team (TAT) to respond to complaints concern[illegible] sour gas smell coming from the release of water from the PSCO reservoir located ne[illegible]

Lake Thomas Site File

SITE ACTIVITIES

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INTRODUCTION

The U. S. Environmental Protection Agency - Emergency Response Branch (EPA) tasked the Ecology & Environment, Inc., Technical Assistance Team (TAT) to respond to complaints concerning a sour gas smell coming from the release of water from the PSCO reservoir located near Mead, Colorado.

SITE ACTIVITIES

The Public Service Company of Colorado (PSCo) owns a reservoir near Mead, Colorado. The reservoir is used to "make up" water diverted lower down at the Fort St. Vrain Power Plant. The reservoir water becomes stagnant at the bottom and releases from the reservoir result in the evolution and release of a sour gas (H_2S) near the outlet works.

TAT responded with air monitoring equipment capable of detecting H_2S. TAT met with Barbara Fiechtner, a resident living next to the Reservoir. Apparently the sour gas is

emitted any time in the late summer when the reservoir releases water. Mrs. Fiechtner is concerned about the health effects of the gas.

After meeting with the Fiechtners, TAT proceeded over to the south abutment of the dam. TAT met with Jesse Brungardt and David Fetteroff from Public Service Company (PSCO). They noted that the sour gas smell has been a recurring problem with the reservoir. Influents to the reservoir include discharges from the town of Mead sewage lagoons, runoff from agricultural lands, and possibly discharges from the sewage system for a nearby nursing home. Apparently the reservoir releases only when there is a "call" on the river requiring water to be released for other users. Much of the time the reservoir remains stagnant. With hot weather, the types of influent, and stagnant water, the lower levels of the lake can become depleted of oxygen resulting in anaerobic decay of material at the bottom of the reservoir. Water releases come from the bottom of the reservoir. When the stagnant water is released it is aerated at the discharge point. At this point the H_2S in the water is released to the atmosphere. Further aeration and release of gas occurs at the measuring flume located downstream of the outlet works.

Below the outlet works the water continues down a low lying gulch toward the St. Vrain river located approximately 2 1/2 miles away. Crops are cultivated along the sides of the gulch indicating that farm workers regularly visit the low lying areas.

TAT used a MSA 361 gas indicator for measuring the H_2S at the outlet works and at the measuring flume. In the outlet works the measurement was 170 ppm. At the breathing zone, approximately 8 feet away and up from the discharge pipe the reading was 6 ppm. At the flume the measurement was 10 ppm near the water.

The NIOSH guidebook lists both NIOSH and OSHA exposure limits (TWA) of 10 ppm for H_2S. The IDLH from the guidebook is 300 ppm. NIOSH recommends an air supplied respirator of SCBA for levels above 100 ppm.

The Fiechtners have complained to PSCo for approximately 15 years about the problem. Generally the releases occur 24 hours a day during the "river call". This year, with the assistance of the State Water Commissioner, the releases are occurring only between 6 am and 6 pm to allow for nighttime use of the two nearby houses. The daytime conditions (heat and wind) tend to disperse the gas. Conditions at night (still, cool air) will tend to concentrate the heavier than air H_2S in lower lying areas.

PSCo has attempted to rectify the situation in the past. Approximately three years ago an aerator was installed on the reservoir to improve circulation and prevent the anaerobic conditions from developing. Unfortunately, the aerator was a surface aerator and did not

reach down to the 37 foot maximum depth of the reservoir. The motor on the aerator was removed three years ago and has not been replaced.

CONCLUSIONS

The H_2S levels in the outlet works pose a danger to anyone working of playing in the outlet works. The levels measured at the flume and water interface could exceed the OSHA standard if a person spent a lot of time in the area.

RECOMMENDATIONS

For the long term problem there are several methods which may reduce or eliminate the buildup of the stagnant conditions and/or H_2S in the reservoir.

1. The influents coming into the reservoir are probably high in nitrogen which will contribute to the growth of aquatic plants and the depletion of oxygen at depth in the reservoir. Also, the sewage discharges are likely high in Biologic Oxygen Demand (BOD) which will also contribute to the degradation of the water quality in the reservoir. An evaluation (sampling) of all the influents may suggest that only a few are contributing to the problem in the reservoir. These specific influents could then be examined for possible ways to improve the quality of water entering the reservoir. Where possible, passive systems should be installed to minimize the maintenance required. For example, from the Mead lagoon outfall, possibly drop structures could be installed into the ditch to improve the aeration of the effluent/influent.

2. Aerate or circulate the water in the reservoir. This could be accomplished by the installation of an aerator or paddle mixer which reaches the bottom of the reservoir. By adding air to the bottom of the reservoir the development of the anaerobic conditions which are contributing to the development and release of H_2S from the reservoir could be eliminated. The most effective system would probably be a tube aeration system which would not be affected by minor fluctuations in water level. A paddle mixer would require constant adjustment as the water levels changed.

3. Create flow-through conditions in the reservoir. The goal is to prevent the formation of a 'dead' layer in the reservoir. This could be accomplished by running water

continuously into the reservoir and out through and overflow structure. The overflow structure should be constructed to remove water from the bottom of the reservoir through a riser to the outlet. This situation will work best during wet years when there is available excess water. This solution should work if it is implemented on a continual basis. This is probably best accomplished by draining the reservoir, installing the overflow structure, filling the reservoir, and keeping water flowing through the structure. This may be possible through the use of BIG T water shares for 'dry' times and by appropriating water whenever 'free river' conditions prevail.

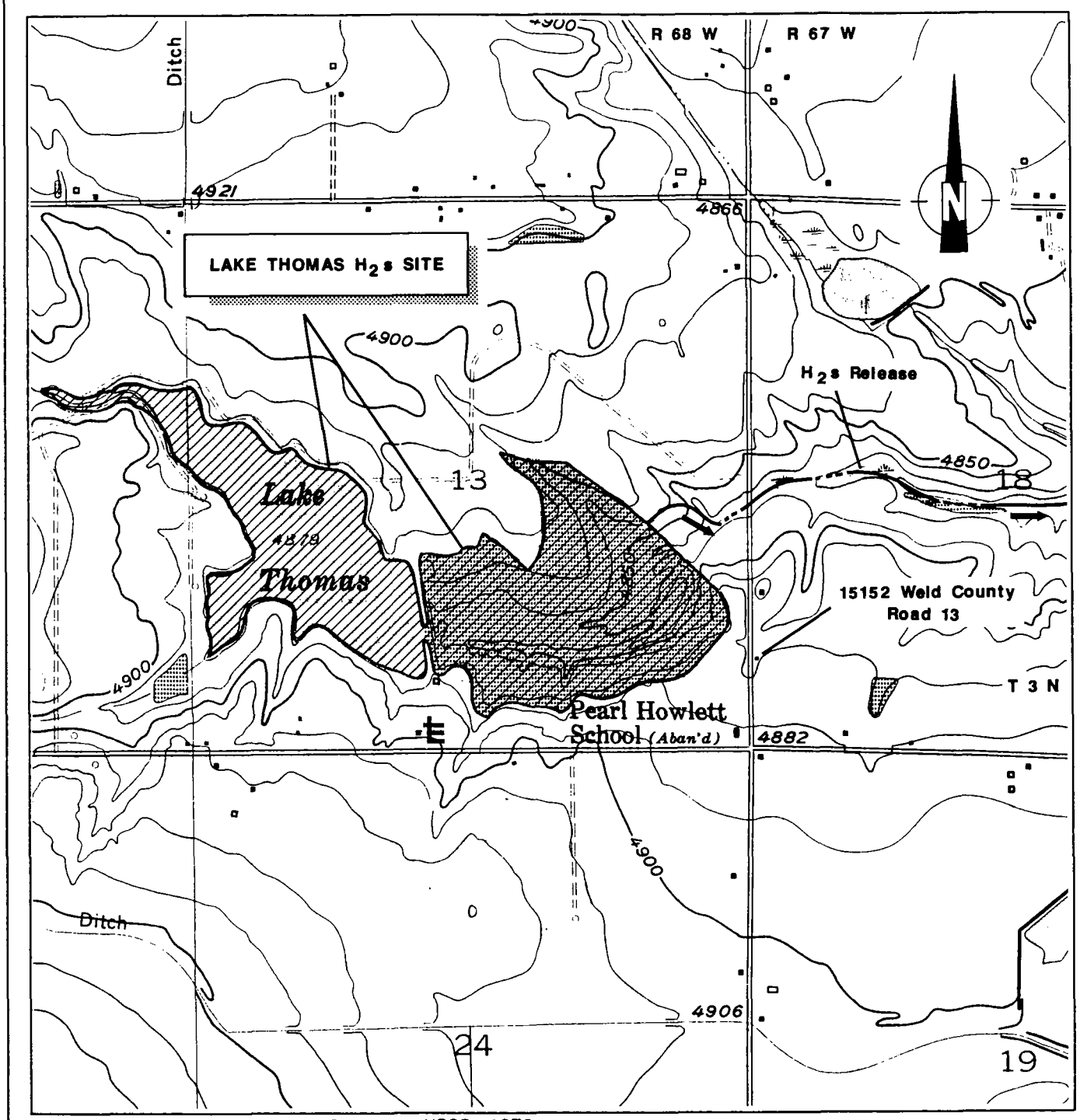
Immediate solutions to the problem all include a release of the presently built up H_2S and include:

1. Drain the reservoir. Draining will still entail the release of H_2S, but will compress the time of odor problems. The potential exists for generating higher levels of H_2S in the vicinity of the residents.

2. Stop all discharges from the reservoir. This is complicated by the requirements to release water as required by the State Water Commissioner. Also this does not solve the problem presently at the bottom of the reservoir.

3. Install an effective aeration system. A system which transports air to the bottom of the reservoir will begin the mixing process in the reservoir. Unfortunately this will result in the generation and release of the H_2S at the surface of the reservoir. Release at the surface of the reservoir, where their is air circulation, may prevent the pooling and concentration presently occurring at the low levels near the outlet works.

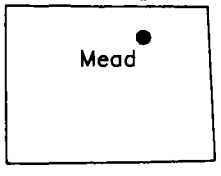
TAT also recommends time weighted air sampling be conducted near the outlet works, downstream in the low areas, and in the two houses near the reservoir to determine if a health problem exists. Releases at night are particularly important to document as the still, cool air (generally conditions found at night), will contribute to the concentration of H_2S in low lying areas.



Source: Gowanda Quadrangle, Colorado. USGS, 1979

0 .5 1 MILE

LOCATION MAP
COLORADO



LEGEND

Site location

TECHNICAL ASSISTANCE TEAM FOR EMERGENCY RESPONSE, REMOVAL AND PREVENTION EPA CONTRACT 68-WO-0037	
TITLE: LAKE THOMAS H_2s SITE Weld County, Colorado SITE LOCATION MAP	
T.D.D. T08-9508-0017	ZTLTH2S
ecology & environment, inc. DENVER, COLORADO	FIG. 1
Date: 08/28/95 Drawn by: RSM Scale:	

APPENDIX A

Tomes Database Printout

NIOSH Pocket Guide(TM)

Topic: HYDROGEN SULFIDE

Chemical Name: Hydrogen sulfide
Structure/formula: H2S
CAS number: 7783-06-4
RTECS number: MX1225000
DOT ID and Guide numbers: 1053 13
Synonyms/trade names: Hydrosulfuric acid, Sewer gas, Sulfuretted hydrogen
Conversion factor at 68 degrees and 760 mmHg: 1 ppm = 1.42 mg/m3
Exposure Limits:
- NIOSH recommended exposure limits (RELs): Ceiling REL 10 ppm (15 mg/m3) (10-minute)
- OSHA permissible exposure limits (PELs): OSHA PEL@: Ceiling REL 20 ppm 50 ppm (10-minute maximum peak)

IDLH: 100 ppm
Physical Description: Colorless gas with a strong odor of rotten eggs.
Notes: (Note: Sense of smell becomes rapidly fatigued & can NOT be relied upon to warn of the continuous presence of H2S. Shipped as a liquefied compressed gas.)
Chemical and physical properties:
- Molecular weight: 34.1
- Boiling point: -77 deg. F
- Solubility in water (% by weight): 0.4%
- Flash point: Not applicable (Gas)
- Ionization potential: 10.46 eV
- Relative density of gases (air = 1): 1.19
- Flammability: Flammable Gas
- Vapor pressure: 17.6 atm
- Freezing point: -122 deg. F
- Upper explosive limit in air (% by volume): 44.0%
- Lower explosive limit in air (% by volume): 4.0%

Incompatibilities and reactivities: Strong oxidizers, strong nitric acid, metals
Measurement method: Charcoal tube; NH4OH/Hydrogen peroxide; Ion chromatography; NIOSH Manual of Analytical Methods, 3rd Edition (#6013)
Personal protection and sanitation:
- Wear appropriate personal protective clothing to prevent the skin from becoming frozen from contact with the liquid or from contact with vessels containing the liquid.
- Wear appropriate eye protection to prevent eye contact with the liquid that could result in burns or tissue damage from frostbite.
- No recommendation is made specifying the need for washing the substance from the skin (either immediately or at the end of the work shift).
- Work clothing that becomes wet should be immediately

removed due to its flammability hazard (i.e., for liquids with a flash point < 100 F).

No recommendation is made specifying the need for the worker change clothing after the work shift.

Quick drench facilities and/or other eyewash fountains should be provided within the immediate work ares for emergency use where there is any possibility of exposure to liquids that are extremely cold or rapidly evaporating.

Recommendations for respirator selection:

NIOSH

100 ppm: Any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern (Assigned protection factor = 25); or Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern (Assigned protection factor = 50); or Supplied-air respirator Substance reported to cause eye irritation or damage; may require eye protection/Any self-contained breathing apparatus with a full facepiece (Assigned protection factor = 50)

Emergency or planned entry into unknown concentrations or IDLH conditions: Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode (Assigned protection factor = 10,000); or Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode (Assigned protection factor = 10,000)

Escape: Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern (Assigned protection factor = 50); or Any appropriate escape-type, self-contained breathing apparatus

Health Hazards:

Exposure routes: Inhalation; Skin and/or eye contact;

Exposure symptoms: irritation eyes, respiratory system; apnea, coma, convulsions; conjunctivitis, eye pain, lacrimation (discharge of tears), photophobia (abnormal visual intolerance to light), corneal vesiculation; dizziness, headache, fatigue, irritability, insomnia; gastrointestinal disturbance; liquid: frostbite

First aid:

If the eye tissue is frozen, seek medical attention immediately; if tissue is not frozen, immediately

and thoroughly flush the eyes with large amounts of water for at least 15 minutes, occasionally lifting the lower and upper eyelids. If irritation, pain, swelling, lacrimation, or photophobia persist, get medical attention as soon as possible.

If frostbite has occurred, seek medical attention immediately; do NOT rub the affected areas or flush them with water. In order to prevent further tissue damage, do NOT attempt to remove frozen clothing from frostbitten areas. If frostbite has NOT occurred, immediately and thoroughly wash contaminated skin with soap and water.

Move the exposed person to fresh air at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Target organs: Eyes, respiratory system, central nervous system

Topic: HYDROGEN SULFIDE

TOXICITY/BIOMEDICAL EFFECTS

Summary

Antidote and Emergency Treatment:

1. NITRITE AS AN ANTIDOTE FOR ACUTE HYDROGEN SULFIDE INTOXICATION CAN ONLY BE EFFECTIVE WITHIN THE FIRST FEW MINUTES AFTER THE EXPOSURE, AT WHICH TIME RESUSCITATION AND/OR VENTILATION OF THE VICTIM ARE LIKELY TO PRODUCE CONDITIONS IN WHICH THE NITRITE ACTUALLY SLOWS SULFIDE REMOVAL. **PEER REVIEWED** [BECK JF ET AL; AM J IND HYG ASSOC J 42 (11): 805-9 (1981)
2. A CASE REPORT OF A 34-YEAR-OLD MALE RENDERED UNCONSCIOUS BY EXPOSURE TO A HIGH CONCENTRATION OF HYDROGEN SULFIDE FUMES IS PRESENTED TO ILLUSTRATE THE ADVANTAGES OF OXYGEN THERAPY. SIGNIFICANT IMPROVEMENT IN BLOOD GASES WAS ACHIEVED WITHIN 1 HOUR OF STARTING OXYGEN. THE RISKS OF NITRITE THERAPY ARE DISCUSSED. **PEER REVIEWED** [RAVIZZA G ET AL; VET HUM TOXICOL 24 (AUG): 241-2 (1982)

Medical Surveillance:

1. ANALYSIS OF RETICULOCYTES FOR DELTA-AMINO-LEVULINIC ACID SYNTHASE (AMLEV SYNTHASE) AND HEME SYNTHASE ACTIVITY IN 17 WORKERS IN PULP PRODUCTION WITH LOW-LEVEL HYDROGEN SULFIDE AND METHYLMERCAPTAN EXPOSURE SHOWED DECREASED ACTIVITIES IN 8 AND 6 CASES RESPECTIVELY. THE ASSAY OF AMLEV SYNTHASE AND HEME SYNTHASE COULD BE A VALUABLE ADDITION TO THE ASSESSMENT OF WORKERS' HEALTH IN INDUSTRIES GENERATING HYDROGEN SULFIDE. **PEER REVIEWED** [TENHUNEN P ET AL; CLIN SCI 64 (2): 187-91 (1983)
2. Placement medical examinations should evaluate any existing neurological, eye and respiratory conditions and any history of fainting seizures. It is recommended by NIOSH that placement and periodic examinations (once every 3 years) be made available to all workers occupationally exposed to hydrogen sulfide. **PEER REVIEWED** [Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 513

Toxicity Excerpts

Human Toxicity Excerpts:

1. ... ACTS DIRECTLY UPON NERVOUS SYSTEM, RESULTING IN PARALYSIS OF RESP CENTER, & HAS PARALYZING EFFECT ON OLFACTORY SYSTEM. ... ACTION ... INFLUENCE/S/ LEVEL OF FERRIC HEMOGLOBIN ... WHICH CONTRIBUTES TO ASPHYXIATION. **PEER REVIEWED** [Casarett, L.J., and J. Doull. Toxicology: The Basic Science of Poisons. New York: MacMillan Publishing Co., 1975. 205
2. SYMPTOMATOLOGY: A. LOW TO MODERATELY HIGH VAPOR CONCENTRATIONS: 1. IRRITANT ACTIONS. EYES: PAINFUL CONJUNCTIVITIS, PHOTOPHOBIA, LACRIMATION, & CORNEAL OPACITY. RESP TRACT: RHINITIS WITH ANOSMIA,

TRACHEOBRONCHITIS WITH PAIN AND COUGH, PULMONARY EDEMA WITH DYSPNEA, SOMETIMES LATE BRONCHOPNEUMONIA. SKIN: DIRECT CONTACT (AS SOLN) MAY PRODUCE ERYTHEMA & PAIN. B. VERY HIGH VAPOR CONCENTRATIONS: 1. SUDDEN COLLAPSE & UNCONSCIOUSNESS, WITH OR WITHOUT A WARNING CRY. 2. DEATH FROM PROMPT RESP PARALYSIS, USUALLY WITH TERMINAL ASPHYXIAL CONVULSION. 3. AFTER SUBLETHAL EXPOSURES COMA MAY DISAPPEAR PROMPTLY, BUT FULL RECOVERY IS USUALLY SLOW; THE PATIENT MAY HAVE A RESIDUAL COUGH, CARDIAC DILATATION, SLOW PULSE, PERIPHERAL ... /NEUROPATHY/, ALBUMINURIA AND SOME DEGREE OF AMNESIA OR OF PSYCHIC DISTURBANCE. RECOVERY IS EVENTUALLY COMPLETE IN MOST NONFATAL CASES. **PEER REVIEWED** [Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-200

3. A CASE OF POLYNEURITIS AND ENCEPHALOPATHY FROM 1 DAY EXPOSURE TO A CONCN INSUFFICIENT TO CAUSE LOSS OF CONSCIOUSNESS HAS BEEN REPORTED. **PEER REVIEWED** [American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH:American Conference of Governmental Industrial Hygienists, 1986. 318
4. ANALYSIS OF RETICULOCYTES FOR DELTA-AMINO-LEVULINIC ACID SYNTHASE (AMLEV SYNTHASE) AND HEME SYNTHASE ACTIVITY IN WORKERS IN PULP PRODUCTION WITH LOW-LEVEL HYDROGEN SULFIDE AND METHYLMERCAPTAN EXPOSURE SHOWED DECREASED ACTIVITIES. ERYTHROCYTE PROTOPORPHYRIN CONCENTRATION WAS BELOW THE CONTROL RANGE IN 7 CASES. LOW AMLEV SYNTHASE AND HEME SYNTHASE ACTIVITIES WERE FOUND IN 1 PATIENT WITH HYDROGEN SULFIDE INTOXICATION 1 WEEK AFTER THE EVENT. THE ACTIVITIES HAD RETURNED TO THE CONTROL LEVELS 2 MONTHS LATER, THOUGH ERYTHROCYTE PROTOPORPHYRIN REMAINED ABNORMALLY LOW. IN VITRO, HYDROGEN SULFIDE INHIBITED HEME SYNTHASE WITH AN APPARENT KI OF 3.4 MMOL/L. SULFIDE ANION INHIBITED AMLEV SYNTHASE ACTIVITY 85% AT 10 MMOL/L. **PEER REVIEWED** [TENHUNEN P ET AL; CLIN SCI 64 (2): 187-91 (1983)
5. SPONTANEOUS ABORTIONS WERE ANALYZED IN AN INDUSTRIAL COMMUNITY IN FINLAND IN WOMEN WHO WERE EMPLOYED IN RAYON TEXTILE JOBS AND PAPER PRODUCTS JOBS. AN INCREASED RATE OF SPONTANEOUS ABORTIONS WAS NOTED IN ALL SOCIOECONOMIC CLASSES IN AREAS WHERE THE MEAN ANNUAL LEVEL OF HYDROGEN SULFIDE EXCEEDED 4 UG/CU M. HOWEVER, THE DIFFERENCE (TOTAL RATES 7.6 AND 9.3, RESPECTIVELY) WAS NOT STATISTICALLY SIGNIFICANT. **PEER REVIEWED** [HEMMINKI K, NIEMI ML; INT ARCH OCCUP ENVIRON HEALTH 51 (1): 55-63 (1982)
6. HYDROGEN SULFIDE IS ASSOCIATED WITH DEATHS CAUSED BY FERMENTING MANURE. **PEER REVIEWED** [MORSE DL ET AL; JAMA

25 (1): 63-4 (1981)

7. HYDROGEN SULFIDE CAN PENETRATE SKIN & CAUSE TOXICOSIS IN PEOPLE EXPOSED TO LARGE CONCN OVER LONG PERIOD ... SPEED OF ONSET OF ACUTE HYDROGEN SULFIDE POISONING & POTENCY OF HYDROGEN SULFIDE ARE ALMOST SAME AS FOR CYANIDE GAS ... **PEER REVIEWED** [Jones, L.M., et al. Veterinary Pharmacology & Therapeutics. 4th ed. Ames: Iowa State University Press, 1977. 1161
8. POISONING WITH HYDROGEN SULFIDE ... HAS BEEN DESCRIBED FROM DRINKING CONTAMINATED WATER. **PEER REVIEWED** [Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 82
9. Low concentrations of 20-150 ppm cause irritation of the eyes; slightly higher concentrations may cause irritation of the upper respiratory tract, and if exposure is prolonged, pulmonary edema may result. The irritant action has been explained on the basis that hydrogen sulfide combines with the alkali present in moist surface tissues to form sodium sulfide, a caustic. **PEER REVIEWED** [Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 1552
10. Lethal blood concentration: 0.092 mg %. **PEER REVIEWED** [Winek, C.L. Drug and Chemical Blood-Level Data 1985. Pittsburgh, PA: Allied Fischer Scientific, 1985.
11. ... OF 174 EXPOSURES TO HYDROGEN SULFIDE IN A HEAVY WATER PLANT ... EYE IRRITATION WAS RELATIVELY UNCOMMON. MORE COMMON FINDINGS WERE NERVOUSNESS, COUGH, NAUSEA, HEADACHE & INSOMNIA. **PEER REVIEWED** [American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH:American Conference of Governmental Industrial Hygienists, 1986. 318
12. At a concentration of 150 ppm, the olfactory nerve is paralyzed. **PEER REVIEWED** [USEPA; Health and Environmental Effects Profile for Hydrogen Sulfide p.118-8 (1980) ECAO-CIN-026A
13. Hydrogen sulfide is an extremely hazardous gas which can be immediately life threatening at high concentrations (300 mg/cu m or 200 ppm). **PEER REVIEWED** [NIOSH: Occupational Exposure to Hydrogen Sulfide p.79 (1977) DHEW (NIOSH) Publication # 77-158
14. 1400-2,800 mg/cu m inhalation <20 min number of subjects 342, hospitalization of 320, death of 22, residual nervous system damage in 4. **PEER REVIEWED** [McCabe LC, Clayton GD; Arch Ind Hyg Occup Med (6): 199-213 (1952) as cited in NIOSH: Occupational Exposure to Hydrogen Sulfide; p.61 (1977) DHEW (NIOSH) Publication # 77-158
15. Concentrations of 20-50 ppm irritates the eyes. Inhalation

of 500 ppm for 30 minutes produces headache, dizziness, excitement, staggering, and gastroenteric disorders followed in some cases by bronchitis or bronchial pneumonia. Concentrations above 600 ppm can be fatal within 30 minutes through respiratory paralyses. **PEER REVIEWED** [Matheson; Guide to Safe Handling of Compressed Gases 2nd ED p.15 (1983)

Non-Human Toxicity Excerpts:

1. SUDDEN DEATH FROM INHALATION OF LARGE CONCN OF HYDROGEN SULFIDE DUE TO INHIBITION OF CELLULAR RESP IN VITAL TISSUES, PARTICULARLY BRAIN. ... APPARENTLY ... INHIBIT/S/ CYTOCHROME OXIDASE, THUS INHIBITING ELECTRON-TRANSPORT SYSTEM. **PEER REVIEWED** [Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 9602
2. IF EXPOSURE IS NOT TOO GREAT, COUGHING, LACRIMATION, MUCOUS NASAL DISCHARGE, DYSPNEA, DEPRESSION, FLUID SOUNDS IN LUNGS, & TERMINAL CYANOSIS & POSSIBLE CONVULSIONS MAY OCCUR. LARGE CONCN OF HYDROGEN SULFIDE MAY CAUSE SUDDEN COLLAPSE, CYANOSIS, DYSPNEA, ANOXIC CONVULSIONS, & RAPID DEATH. THERE MAY BE PULMONARY EDEMA & EDEMA OF INTESTINES & BRAIN. BLOOD IS DARK & FAILS TO CLOT. HEMORRHAGES MAY OCCUR IN VARIOUS ORGANS. LIVER & KIDNEY MAY MANIFEST DEGENERATIVE CHANGES. **PEER REVIEWED** [Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 9602
3. IN ANIMAL EXPT TEMPORARY DAMAGING EFFECT ... ON CORNEAL EPITHELIUM HAS ... BEEN DEMONSTRATED ON ... DOGS, CATS, RABBITS, & GUINEA PIGS ... USUALLY BY EXPOSURE TO 50 TO 100 PPM FOR SEVERAL HR OR DAYS. **PEER REVIEWED** [Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 496
4. THERE HAVE BEEN NUMEROUS RECORDS OF PIGS HAVING BEEN FATALLY POISONED BY HYDROGEN SULFIDE RELEASED /GAS/ FROM SLURRY TANKS IN PIGGERIES WHEN SLURRY HAS BEEN AGITATED PRIOR TO PUMPING. UNDER THESE CONDITIONS GAS CAN RAPIDLY BUILD UP TO A TOXIC LEVEL (80-800 PPM); AND ON OCCASIONS MEN WORKING ON THE SITE HAVE BEEN OVERCOME. CATTLE HAVE ALSO BEEN POISONED IN THIS WAY; CALVES SHOWED ATAXIA & ENTERITIS. ... ALTHOUGH SUDDEN EXPOSURE TO CONCN OF 0.04% MIGHT BE FATAL TO PIGS, THERE WERE NO PERMANENT ILL EFFECTS IN ANIMALS SURVIVING EXPOSURE TO 0.1% /OBSERVED/. **PEER REVIEWED** [Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 82
5. CASES POULTRY POISONING HAVE ... BEEN RECORDED. /AN/ EPISODE OCCURRED IN A BATTERY LAYING HOUSE; BIRDS AFFECTED WERE NEAREST /TO/ THE GROUND & TO A LEAKING MANHOLE COVER.

Topic: HYDROGEN SULFIDE

ANALYSIS OF FUMES REVEALED THAT WHILE OTHER GASES WERE PRESENT IN ACCEPTABLE CONCN; HYDROGEN SULFIDE ALONE EXCEEDED SAFE LIMITS. **PEER REVIEWED** [Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 82

6. EXPOSURE OF CHANNEL CATFISH TO 0.5 MG/L HYDROGEN SULFIDE AT 20 DEG C RESULTED IN HYPERPNEA, FOLLOWED BY APNEA AND RESPIRATORY ARREST. **PEER REVIEWED** [TORRANS EL, CLEMENS HP; COMP BIOCHEM PHYSIOL C COMP PHARMACOL 71 (2): 183-190 (1982)
7. AT HIGH CONCN HYDROGEN SULFIDE PRODUCES PARALYSIS OF OLFACTORY NERVES (ANOSMIA) & ODOR DETECTION IS INEFFECTIVE AS A WARNING FOR HYDROGEN SULFIDE. **PEER REVIEWED**
8. /Ten species of weeds 3 to 6 weeks of age were/ fumigated with 100 to 500 ppm hydrogen sulfide for four hours. /Results suggested that/ differences in susceptibility to injury /existed/ and ... that younger plants were more sensitive to damage than older ones. /Data also suggested/ that increases in temperature exacerbated the damage, as did dry soil. **PEER REVIEWED** [Benedict HM et al; National Air Pollution Symposium p. 177-90 (1955) as cited in USEPA; Health Assessment Document for Hydrogen Sulfide (Draft) p. 5-2 (1986)

Toxicity Values

Human Toxicity Values:

1. Man: severe toxic effects 200 ppm = 280 mg/cu m 1 min; symptoms of illness 50 ppm = 70 mg/cu m; unsatisfactory: 20 ppm = 28 mg/cu m **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
2. Man: lethal: 600 ppm/30 min; 800 ppm, immediate /lethality/ **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745

Non-Human Toxicity Values:

1. LC50 Rhesus monkey inhalation 700 mg/cu m/35 min. **PEER REVIEWED** [Lund OE, Wieland H; Int Arch Gewerbepathol Gewerbehyg 22: 46-54 (1966)
2. LC50 Mouse inhalation 1500 mg/cu m/18 min **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
3. LC50 Mouse inhalation 380 mg/cu m/410 min **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
4. LC50 Mouse inhalation 96 mg/cu m/804 min **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold

Co., 1983. 745
5. LC50 Mouse inhalation 24 mg/cu m/ > 960 min **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
6. LC50 Rat inhalation 1500 mg/cu m/14 min **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
7. LC50 Rat inhalation 380 mg/ cu m > 960 min **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745

Ecotoxicity Values:
1. TLm Asellus sp 0.111 mg/l/96 hr /Conditions of bioassay not specified/ **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 744
2. TLm Crangonyx sp 1.07 mg/l/96 hr /Conditions of bioassay not specified/ **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 744
3. TLm Gammarus sp 0.84 mg/l/96 hr /Conditions of bioassay not specified/ **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 744
4. LC50 Fly inhalation 380 mg/cu m/ > 960 min **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
5. LC50 Fly inhalation 1500 mg/cum/7 min **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
6. TLm Lepomis macrochirus (bluegill sunfish) eggs 0.0190 mg/l/72 hr at 21-22 deg C in a flow through bioassay **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
7. TLm Lepomis macrochirus (bluegill sunfish) 35 day old fry 0.0131 mg/l/96 hr at 21-22 deg C in a flow through bioassay **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
8. TLm Lepomis macrochirus (bluegill sunfish) juveniles 0.0478 mg/l/96 hr at 21-22 deg C in a flow through bioassay **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745

9. TLm Lepomis macrochirus (bluegill sunfish) adults 0.0448 mg/l/96 hr at 21-22 deg C in a flow through bioassay **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
10. TLm Pimephales promelas (fathead minnow) 0.0071-0.55 mg/l/96 hr at 6-24 deg C in a flow through bioassay **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745
11. TLm Salvelinus fontinalis (brook trout) 0.0216-0.038 mg/l/96 hr at 8-12.5 deg C in a flow through bioassay **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 745

Pharmacokinetics

Absorption, Distribution and Excretion:

1. ... Hydrogen sulfide is readily absorbed through the skin, lung and digestive tract lining. ... Some of the sulfide may be trapped by natural disulfides in the bloodstream. Some sulfide is also excreted as iron sulfide in feces. **PEER REVIEWED** [Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 959

Metabolism/Metabolites:

1. ... In the bloodstream the gas is converted to alkali sulfide. The hydrosulfide radical is excreted by the lungs and in urine. Part of the sulfide is oxidized to sulfate and thiosulfate ... . **PEER REVIEWED** [Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 959

Mechanism of Action:

1. HYDROSULFIDE ANION (HS-) ... FORMS COMPLEX WITH METHEMOGLOBIN KNOWN AS SULFMETHEMOGLOBIN, WHICH IS ANALOGOUS TO CYANMETHEMOGLOBIN. ... DISSOCIATION CONSTANT FOR SULFMETHEMOGLOBIN HAS BEEN EST AS 6X10-6 MOLES/L WHERE AS THE DISSOCIATION CONSTANT FOR CYANMETHEMOGLOBIN IS ABOUT 2X10-8 MOLES/L. DESPITE LOWER BINDING AFFINITY FOR SULFIDE, INDUCED METHEMOGLOBINEMIA PROVIDES UNEQUIVOCAL PROTECTION AGAINST DEATH FROM ACUTE SULFIDE POISONING IN ANIMALS. **PEER REVIEWED** [Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 242
2. THE ABSORPTION OF HYDROGEN SULFIDE (H2S) GAS BY SCIATIC NERVE BUNDLES FROM RANA PIPIENS PRODUCES AN ANESTHETIC EFFECT OF SHORT DURATION. UNLIKE HYDROGEN CYANIDE THERE IS NO INDICATION THAT HYDROGEN SULFIDE INHIBITS THE ENERGY METABOLISM OF THE NERVE CELLS, EXCEPT POSSIBLY WHEN THE NERVES ARE EXPOSED TO EXTREMELY HIGH SULFIDE

Topic: HYDROGEN SULFIDE

CONCENTRATIONS. A MODE OF ACTION FOR HYDROGEN SULFIDE IS PROPOSED. **PEER REVIEWED** [BECK JF ET AL; TOXICOLOGY 26 (1): 37-45 (1983)

3. Hydrogen sulfide is a ... potent inhibitor of the cytochrome oxidase system ... . **PEER REVIEWED** [Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 837

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: Panorama of Thomas Reservoir from south side.

Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1208 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT


8 18 95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8 18 95

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: Discharge area below dam.

Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1212 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: Outlet works valve house.

Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1212 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: Outlet works - discharge side.

Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1220 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: Grate over outlet works. H_2S reading is 170 ppm in outlet works.
Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1233 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: ~~Partial~~ PARSHALL measuring flume. H_2S reading is 10 ppm.

Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1240 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: Aeration occurring at downstream ~~partial~~ of Parshall measuring flume.
Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1240 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: Harvey Fiechtner house from outlet - discharge area.

Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1245 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: Harvey Fiechtner house from dam.

Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1255 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT

OFFICIAL PHOTOGRAPH
ENVIRONMENTAL PROTECTION AGENCY

Subject: Barbara Fiechtner house from dam.

Site: Lake Thomas H_2S Site
City: Near Mead County: Weld State: CO
Date: August 18, 1995 Time: 1255 Hours
Photographer: Mike Sullivan
Film: Kodak ASA: 200 Location of Negative: EPA-ERB
File: T08-9508-017
Witness: Tom Koger
Process: C-41
Paper: AGFA

[PHT]9508-017.PHT